

DEPARTMENT OF MECHANICAL ENGINEERING & MECHANICS
COLLEGE OF ENGINEERING & TECHNOLOGY
OLD DOMINION UNIVERSITY
NORFOLK, VIRGINIA 23529

**NAVIER-STOKES CALCULATIONS OF
SCRAMJET-NOZZLE-AFTERBODY FLOWFIELDS**

By

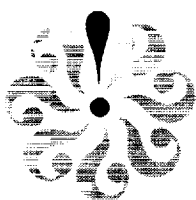
Oktay Baysal, Principal Investigator

Final Report
For the period ended August 15, 1991

Prepared for
National Aeronautics and Space Administration
Langley Research Center
Hampton, Virginia 23665

Under
Research Grant NAG-1-811
James L. Pittman, Technical Monitor
SMD-Aerothermal Loads Branch

Submitted by the
Old Dominion University Research Foundation
P.O. Box 6369
Norfolk, Virginia 23508-0369



July 1991

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OF SCRAMJET-NOZZLE-AFTERBODY FLOWFIELDS
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**Oktay Baysal
Old Dominion University
Norfolk, Virginia**

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The geometry of a wind tunnel model, which had been built for similar purposes, has been adopted in order to facilitate the necessary CFD code validation with the experimental results. Internal and external portions of the nozzle were included in the computational domain. All the calculations have assumed cold exhaust gases as have the wind tunnel tests. Also, the thermodynamic similitude has been maintained in one set of computations by using a cold gas mixture, which has a specific heat ratio (γ) equal to that of the hot exhaust gas.

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Mohamed E. Elshaky

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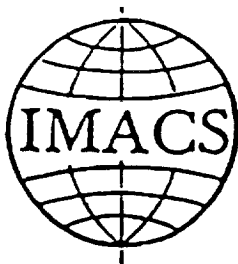
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Mathematical Physics Ph.D. Program**



Conference Program

**University of Colorado at Boulder
Boulder, Colorado**

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Propulsion-airframe integration for hypersonic airbreathing vehicles is an important feature for the design of a national aero-space plane configuration. The lower afterbody expands the supersonic exhaust gases from the scramjet engine, therefore it becomes a part of the nozzle. This strong coupling between the engine and the airframe necessitates a combined analysis of internal and external flows. The hypersonic freestream and the supersonic exhaust flow mix through a shear layer, where mass, momentum, and energy transfers occur. The interference of the exhaust on the control surfaces of the aircraft can have adverse effects on the stability of the aircraft. Therefore, some method of simulating this type of flow is required to properly design the nozzle and the afterbody region.

A simplified configuration is assumed to model the single-module scramjet nozzle and afterbody. A rectangular duct precedes the internal nozzle, which has a 12° upper surface and a 20° lower surface. The external part of the nozzle is bounded by a 20° ramp and a vertical reflection plate. The external hypersonic flow is initially over a double-corner formed by the reflection plate, the top surface of the nozzle, the exterior of the nozzle sidewall, and a side flat plate. The viscous effects become dominant in all the corner regions. Then both of the flows expand over the 20° ramp. The supersonic jet expands in the axial, the normal, and the spanwise directions as it clears the exit plane. A three dimensional shear layer structure is formed between these coflowing streams which are at different speeds.

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**GRANT NAG-1-811
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Paper No. 14

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NASP Contractor Report 1034

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Notice

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THE AMERICAN SOCIETY OF MECHANICAL ENGINEERS
United Engineering Center 345 East 47th Street New York, N.Y. 10017

Navier-Stokes Calculations of Scramjet-Afterbody Flowfields

by

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W. C. Engelund²

Department of Mechanical Engineering and Mechanics
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Hampton, Virginia 23665.

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¹Associate Professor, Mech. Eng. & Mech. Dept.

²Graduate Research Assistant, Mech. Eng. & Mech. Dept.

³Research Engineer, PRC Kentron, SHAB/HSAD

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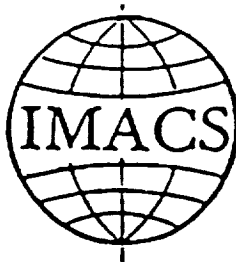
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